

# **EV Market Segmentation**

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## **Problem Statement:**

We need to analyze the Indian EV market using segmentation analysis to identify and target segments most likely to adopt EVs.

## **Key Areas of Focus**

### **1. Segmentation Analysis:**

- **Goal:** Break down the market into distinct, actionable segments.
- **Approach:** Use geographic, demographic, psychographic, behavioral, and other relevant data-based segmentation.

### **2. Target Segments:**

- **Geographic:** Regional EV adoption, infrastructure, policies.
- **Demographic:** Age, income, education, occupation.
- **Psychographic:** Attitudes, values, lifestyles.
- **Behavioral:** Driving habits, usage patterns, purchasing behavior.
- **Other Categories:** Vehicle type (e.g., two-wheelers, cars), business segments (B2B).

### **3. Data Collection Challenges:**

- **Availability:** Not all data is readily available.
- **Research:** Extensive research needed to gather relevant data from various sources.
- **Adaptability:** Adjust segmentation strategy based on data quality and scope.

## **Feasible Strategy for Market Entry**

### **1. Identify Key Segments:**

- Focus on segments with high growth and profitability potential.

### **2. Tailored Marketing and Product Development:**

- Create marketing campaigns and product features that meet segment needs and preferences.

### **3. Infrastructure and Policy Considerations:**

- Consider charging infrastructure and supportive government policies.
- Engage with policymakers for favorable regulations and incentives.

### **4. Iterative Approach:**

- Continuously refine the segmentation strategy based on market feedback and new data.

## Algorithms used:

### 1. Principal Component Analysis (PCA)

**Purpose:** PCA was used to reduce the dimensionality of the dataset while retaining as much variance as possible.

#### How It Helped:

- Simplified the dataset by transforming it into a set of orthogonal (uncorrelated) principal components.
- Made it easier to visualize and interpret the data.
- Helped in identifying underlying patterns and relationships among the variables, which were crucial for further analysis and clustering.

#### Process:

1. **Standardization:** The numerical data was standardized to ensure each feature had a mean of 0 and a standard deviation of 1.
2. **Applying PCA:** PCA was applied to the scaled data to transform it into principal components.
3. **Explained Variance:** The principal components were analyzed to understand the amount of variance explained by each component.

### 2. K-means Clustering

**Purpose:** K-means clustering was employed to segment the market into distinct groups based on their characteristics and behaviors.

#### How It Helped:

- Identified homogeneous groups (clusters) within the dataset.
- Enabled the creation of targeted marketing strategies for different segments.
- Provided insights into the preferences and behaviors of different customer groups.

#### Process:

1. **Determining Optimal Clusters:** The optimal number of clusters was determined using the Elbow Method, which involved plotting the within-cluster sum of squares (WCSS) against the number of clusters and identifying the point where the rate of decrease sharply slows.

2. **Applying K-means:** The K-means algorithm was applied to the principal components derived from PCA.
3. **Interpreting Clusters:** The resulting clusters were analyzed and interpreted to identify key characteristics and preferences of each segment.

## Summary

- **PCA** reduced the dataset's dimensionality, making it easier to analyze and visualize.
- **K-means clustering** segmented the market into distinct groups, providing valuable insights for targeted marketing and strategic decision-making.

## Conclusion and Insights:

### Vehicle Registration Trends

1. **Dominance of Petrol Vehicles:**
  - Petrol remains the dominant fuel type in the Indian vehicle market from 2017 to 2023.
  - However, there is a slight decrease in the dependency on petrol vehicles over the years, indicating a gradual shift in consumer preferences.
2. **Rising Adoption of Electric Vehicles:**
  - The percentage of electric vehicle (EV) registrations has been increasing steadily, reaching 6.8% in 2023.
  - This trend reflects a growing interest in electric mobility, driven by environmental concerns, government incentives, and advancements in EV technology.
3. **Stable Demand for Diesel Vehicles:**
  - Diesel vehicle registrations have shown stable percentages, suggesting consistent demand.
  - This demand is likely influenced by economic factors, industrial requirements, and specific consumer preferences.

### Principal Component Analysis (PCA) and Clustering Insights

4. **Data Simplification and Visualization:**
  - PCA effectively reduced the dimensionality of the dataset, simplifying the analysis and visualization of complex data.
  - The principal components captured the most significant variance in the data, aiding in the identification of underlying patterns.
5. **Market Segmentation:**
  - K-means clustering segmented the market into distinct groups based on their characteristics and behaviors.

- Two key target audiences were identified:
  1. **Environmentally Conscious Early Adopters:**
    - Represented by Cluster 0.
    - Prioritize sustainability and are eager to adopt EVs.
    - Marketing should focus on environmental benefits, addressing charging infrastructure concerns, and showcasing innovative features.
  2. **Price-Conscious Hybrid-Open Consumers:**
    - Identified as Segment 4.
    - Open to both EVs and hybrids.
    - Effective messaging should emphasize price competitiveness, the flexibility of owning both vehicle types, and fuel efficiency.

## **EV Charging Infrastructure**

### **6. Current State of EV Charging Stations:**

- Analysis of EV charging stations on expressways and highways revealed significant insights.
- The **Delhi-Agra Yamuna Expressway** has the highest number of charging stations, reflecting its high traffic volume.
- Several highways lack any EV charging infrastructure, highlighting gaps in the current network.

### **7. Need for Infrastructure Expansion:**

- With a total of 1576 EV charging stations sanctioned across the network, there is a clear need for expansion to support broader EV adoption.
- Expanding the EV charging infrastructure on highways and expressways is crucial for facilitating long-distance travel for EV users.

## **Strategic Recommendations**

Based on the insights gained, the following strategic recommendations are proposed for the EV startup:

### **1. Targeted Marketing:**

- Develop marketing campaigns tailored to the environmentally conscious early adopters, emphasizing the environmental benefits and innovative features of EVs.
- Create campaigns for price-conscious hybrid-open consumers, focusing on price competitiveness and the advantages of owning both EVs and hybrids.

### **2. Infrastructure Development:**

- Collaborate with government and private entities to expand the EV charging infrastructure, especially on key highways and expressways.

- Prioritize areas with high traffic volumes and existing gaps in the charging network.
- 3. **Product Innovation:**
  - Invest in R&D to enhance the features and performance of EVs, addressing common consumer concerns such as range anxiety and charging time.
  - Introduce hybrid models to attract consumers who are open to both EVs and hybrids.
- 4. **Policy Advocacy:**
  - Engage with policymakers to advocate for supportive regulations and incentives for EV adoption.
  - Encourage the development of a robust EV ecosystem, including charging infrastructure, maintenance services, and battery recycling facilities.

## **Improvements if given extra resources:**

Given additional time and a budget to purchase data, several improvements can be made to enhance the market segmentation project. The enhancements would focus on collecting more comprehensive datasets and applying additional machine learning models to refine the analysis and segmentation.

## **Improved Datasets Collection**

### **Additional Data Sources and Columns**

1. **Detailed Consumer Demographics:**
  - Age
  - Gender
  - Income Level
  - Education Level
  - Occupation
  - Geographic Location (Urban, Suburban, Rural)
2. **Behavioral Data:**
  - Driving Habits (Daily Commute Distance, Long-Distance Travel Frequency)
  - Vehicle Ownership History (Previous Fuel Types Owned, Number of Vehicles Owned)
  - Environmental Concerns (Interest in Sustainability, Willingness to Pay for Green Products)
3. **Vehicle-Specific Data:**
  - Vehicle Price Range
  - Vehicle Features and Specifications (Battery Capacity, Range, Charging Time, Safety Features)

- Ownership Costs (Maintenance Costs, Insurance Costs)
- Purchase Incentives (Government Subsidies, Tax Benefits)
- 4. **Charging Infrastructure Data:**
  - Availability of Home Charging Stations
  - Proximity to Public Charging Stations
  - Charging Costs (Home vs. Public)
  - Charging Network Coverage (Urban vs. Rural)
- 5. **Market Trends and External Factors:**
  - Fuel Price Trends
  - Government Policies and Regulations
  - Economic Indicators (Inflation Rate, Employment Rate)
  - Technological Advancements (New EV Technologies, Battery Innovations)

## **Additional Machine Learning Models**

1. **Hierarchical Clustering:**
  - Provides a different approach to market segmentation by creating a dendrogram, which helps visualize the hierarchy of clusters and can reveal more granular insights into customer segments.
2. **Gaussian Mixture Models (GMM):**
  - Allows for soft clustering, where data points can belong to multiple clusters with different probabilities. This can provide a more nuanced understanding of customer segments.
3. **Random Forest Classifier:**
  - Can be used for feature importance analysis, helping identify the most influential factors driving consumer preferences and behaviors.
4. **Gradient Boosting Machines (GBM):**
  - Offers robust predictive capabilities and can help refine the segmentation model by handling complex, non-linear relationships in the data.
5. **Neural Networks:**
  - Particularly useful for capturing intricate patterns and interactions within the data, potentially leading to more accurate and insightful segmentation.
6. **Customer Lifetime Value (CLV) Prediction:**
  - Implementing models to predict CLV for each segment can help prioritize marketing efforts and resource allocation based on the long-term value of different customer groups.

## **Implementation Plan**

1. **Data Acquisition:**

- Purchase and integrate detailed demographic, behavioral, and vehicle-specific datasets from reliable sources such as market research firms, automotive industry reports, and government databases.
  - Collect additional charging infrastructure data and market trend information to provide a holistic view of the EV landscape.
2. **Data Cleaning and Preprocessing:**
    - Ensure data consistency and completeness by addressing missing values, outliers, and inconsistencies.
    - Standardize and normalize data where necessary to facilitate accurate analysis.
  3. **Exploratory Data Analysis (EDA):**
    - Conduct thorough EDA to uncover initial insights, identify correlations, and visualize data distributions and trends.
  4. **Model Training and Evaluation:**
    - Train and evaluate additional ML models such as hierarchical clustering, GMM, random forest, GBM, and neural networks.
    - Compare model performance using metrics such as silhouette score, Davies-Bouldin index, and cross-validation.
  5. **Feature Engineering and Selection:**
    - Apply feature engineering techniques to create new variables that capture important aspects of consumer behavior and preferences.
    - Use feature importance analysis from models like random forest to select the most relevant features for segmentation.
  6. **Segmentation Refinement:**
    - Use the insights from additional ML models to refine the initial segmentation, ensuring that each segment is well-defined and actionable.
    - Conduct qualitative analysis, such as customer surveys and focus groups, to validate and enrich the quantitative findings.
  7. **Actionable Insights and Recommendations:**
    - Develop detailed profiles for each customer segment, including key characteristics, preferences, and pain points.
    - Formulate targeted marketing strategies, product offerings, and infrastructure development plans based on the refined segments.

By leveraging additional datasets and advanced machine learning models, the market segmentation project can achieve deeper insights, more precise segmentation, and ultimately, more effective strategies for the EV startup.

## **Estimation of market size:**

Estimating the market size for the electric vehicle (EV) market in India involves analyzing various factors such as current vehicle sales, projected growth rates, government policies, and

consumer adoption trends. Based on available data and projections, we can provide an estimate for the market size.

### **Current Market Size**

#### **1. Total Vehicle Sales:**

- In 2023, the total number of vehicles sold in India was approximately 3.8 million units, including passenger cars and commercial vehicles.

#### **2. Electric Vehicle Sales:**

- According to industry reports, EV sales accounted for around 6.8% of total vehicle sales in 2023.
- This translates to approximately 258,400 electric vehicles sold in 2023 (6.8% of 3.8 million).

### **Projected Market Growth**

#### **1. Government Targets and Policies:**

- The Indian government aims to achieve 30% EV penetration by 2030 under the National Electric Mobility Mission Plan (NEMMP).
- Policies such as the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme provide incentives and subsidies to promote EV adoption.

#### **2. Market Growth Rate:**

- The EV market in India is projected to grow at a compound annual growth rate (CAGR) of around 36% from 2023 to 2030, driven by increasing consumer awareness, technological advancements, and supportive government policies.

### **Future Market Size**

To estimate the market size in 2030, we can apply the projected growth rate to the current market size.

#### **1. Formula for Future Market Size:**

$$\text{Future Market Size} = \text{Current Market Size} \times (1 + \text{Growth Rate})^{\text{Number of Years}}$$

#### **2. Calculation:**



$$\text{Future Market Size (2030)} = 258,400 \times (1 + 0.36)^7$$

$$\text{Future Market Size (2030)} \approx 258,400 \times 7.08 \approx 1,829,472 \text{ units}$$

## Summary of Market Size

- **Current Market Size (2023):** Approximately 258,400 electric vehicles.
- **Projected Market Size (2030):** Approximately 1.83 million electric vehicles.

## Top features/variables:

### 1. Income Level

#### Reason:

- Income level significantly influences purchasing power and the ability to invest in new technologies, including electric vehicles.
- Higher income groups may prioritize advanced features and premium models, while lower income groups might focus on cost-effectiveness and affordability.

#### Use in Segmentation:

- Segmenting customers based on income can help tailor marketing messages, financing options, and product offerings to different economic strata.

### 2. Driving Habits

#### Reason:

- Understanding daily commute distances, frequency of long-distance travel, and overall vehicle usage patterns can inform the types of EVs that best suit different customers.
- For instance, urban commuters may prefer compact EVs with shorter ranges, while long-distance travelers might prioritize extended range and fast-charging capabilities.

#### Use in Segmentation:

- Segments based on driving habits can lead to targeted marketing for urban vs. rural consumers, and for those who prioritize efficiency vs. range.

### **3. Environmental Concerns**

#### **Reason:**

- Consumers with high environmental awareness are more likely to adopt electric vehicles due to their lower carbon footprint and sustainable nature.
- This segment is driven by the desire to reduce environmental impact and may be willing to pay a premium for green technologies.

#### **Use in Segmentation:**

- Identifying and targeting environmentally conscious consumers with messages emphasizing sustainability, eco-friendly features, and corporate social responsibility initiatives.

### **4. Vehicle Price Range and Financing Preferences**

#### **Reason:**

- The initial cost of the vehicle and available financing options are critical factors influencing the purchase decision.
- Different price segments (e.g., budget, mid-range, premium) attract different customer profiles.

#### **Use in Segmentation:**

- Segments can be created based on price sensitivity and financing needs, enabling customized offers, flexible payment plans, and targeted promotions.

**Implementation link:** <https://github.com/i23sid/Task-2>